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Developing Collective Training for Small Unmanned Aerial Systems Employment: Workload and Performance with Multiple Systems

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A research simulation environment was developed to investigate training issues concerning employment of small unmanned aerial systems (SUAS) at company and below. The research environment enables simulated platoon missions in a virtual environment in which mounted or dismounted Soldiers control avatars. A person designated as SUAS operator also has the ability to operate a SUAS in the virtual environment. Another person designated as the commander has a command and control tool (C2node), which allows communication and coordination with the SUAS operator (e.g., text messages, mission plans, sensor imagery). Both the operator's control station and the C2node are configurable, to allow investigation of how different features (e.g., providing the C2node with streaming video vs. not) affect mission synchronization and maintenance of a common operational picture. Besides human-controlled avatars, the environment also allows for artificially intelligent non-player characters (NPCs), whose behavior can be scripted via a system of relatively-user friendly menus, prior to a scenario exercise. Experimenters can also take manual control of these NPCs during an exercise. This report describes the capabilities of the environment and an initial experiment providing evidence that users can operate the C2node and an avatar at the same time. The potential for future research application is also discussed.

15. SUBJECT TERMS
unmanned aerial systems, simulation based training, operator control unit, command and control station, artificially intelligent non-player characters, usability, workload

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DEVELOPING COLLECTIVE TRAINING FOR SMALL UNMANNED AERIAL SYSTEMS EMPLOYMENT: WORKLOAD, AND PERFORMANCE WITH MULTIPLE SYSTEMS

EXECUTIVE SUMMARY

Research Requirement:

Over the last several years, unmanned aerial systems (UASs) have been increasingly employed for reconnaissance and surveillance by the U. S. Army. UASs have been assigned at different echelons, typically with size (and capabilities) decreasing with echelon. Moreover, research on developing ever smaller and easier to use UASs continues (e.g., the Defense Advanced Research Project Agency is now funding development of nano-UASs). However, assigning SUASs to units without dedicated staffs or command and control networks (such as at company and below) may raise a number of coordination and communication issues. Currently deployed SUASs do not typically include a networked means of sharing the visual data they can collect. Real-time communication about sensor observations mostly relies on verbal information sharing over FM radio nets and may depend on the aid of intermediaries between the SUAS operator and the ultimate consumer of the information. In addition, SUAS employment requires coordination with manned air assets to avoid collisions and with adjacent units with unmanned systems to avoid radio frequency conflicts. Thus, the training requirements that will be incurred by assigning SUASs to company and below will go beyond operator and maintenance training. It will require training for leaders in mission planning and supervision to allow for the coordinated employment of the SUAS in the context of the unit's larger overall mission (Durlach, 2007). Little attention has been paid thus far to this type of collective training for the employment of SUAS. The research requirement is to determine where problems may arise in the collective employment of SUAS and how these can be addressed, by providing dedicated training on how to avoid these problems, technological support to help overcome these problems, or both. The U. S. Army Unmanned Aircraft Systems Roadmap (2009) predicts that FY 2012 will require training for over 2,100 UAS operators, maintainers, and leaders. The current project created a simulation environment as a mechanism for providing research on the collective training needs that will arise as lower and lower echelons are assigned SUASs.

Procedure:

To meet this need, a research simulation environment was developed to investigate training issues concerning employment of SUAS at company and below. The research environment enables simulated platoon missions in a virtual environment in which mounted or dismounted Soldiers control avatars. A person designated as the SUAS operator has the ability to operate a SUAS in the virtual environment. Another person designated as the commander has a command and control tool (C2node), which allows communication and coordination with the SUAS operator (e.g., text messages, mission plans, sensor imagery). Both the operator's control station and the C2node are configurable, to allow investigation of how different features (e.g., providing the C2node with streaming video vs. not) affect mission synchronization and maintenance of a common operational picture. Besides human-controlled avatars, the environment also allows for artificially intelligent non-player characters (NPCs), whose behavior

can be scripted via a system of relatively-user friendly menus, prior to a scenario exercise. Experimenters can also take manual control of these NPCs during an exercise. This report describes the capabilities of the environment and an initial experiment providing evidence that users can operate the C2node and an avatar at the same time.

After putting these capabilities into place, an initial experiment was conducted to determine the feasibility of the commander being able to operate both the C2node and their avatar simultaneously. Because research participants were from a civilian population, the scenario used during this experiment was a non-military search and identification mission. This task was created to incorporate activities that would be elements of more realistic maneuver platoon missions. It required each participant to identify objects in pictures sent to the C2node and simultaneously to identify specific avatars within the virtual environment. Workload was varied over trials by additional tasks being added to both the C2node and the virtual environment. Participants performed over four trials which consisted of high and low workload combinations within both C2node and the game environment. Specifically, the four trials consisted of the baseline tasks (search and identify tasks), the baseline plus an additional task in C2node, baseline plus an additional task in the game environment, and baseline plus additional tasks in both C2node and the game environment.

Findings:

Participants were able to operate the two system components, with performance improving over trials. Task performance was affected by both video game use and spatial ability, with higher spatial ability and more video game use associated with higher performance. Performance and perceived workload were significantly affected by the workload manipulation, but the effects were small compared with the beneficial effects of practice (i.e., participant performance improved over practice trials), which bodes well for the use of this environment to investigate more tactically relevant mission scenarios. Additionally, based on usability questions, the overall reaction to and perceived usability of the system was favorable.

Utilization and Dissemination of Findings:

The procedures the participants were asked to perform in this experiment were different than those of a platoon leader in the field. Nevertheless, the experiment demonstrated that users can quickly learn to use the C2node and the game environment simultaneously. Furthermore, despite perceptions of workload and differences in performance based on workload conditions, participants still improved overall by the fourth trial. This indicated that the environment has the potential to support investigation of more mission-relevant behaviors. This work has been presented at the conference MODSIM WORLD 2010. In addition, the software has been made available to contractors (i.e., SA Technologies, Design Interactive, Alion, Inc.) for research purposes.

DEVELOPING COLLECTIVE TRAINING FOR SMALL UNMANNED AERIAL SYSTEMS EMPLOYMENT: WORKLOAD AND PERFORMANCE WITH MULTIPLE SYSTEMS

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Introduction

Over the last several years, unmanned aerial systems (UASs) have been increasingly employed for reconnaissance and surveillance by the U. S. Army, which has over 4,000 UASs of various sizes and capabilities at its disposal (U.S. Army Roadmap for UAS 2010 – 2035, 2009). UASs have been assigned at different echelons, typically with size (and capabilities) decreasing with echelon. Moreover, research on developing ever smaller and easier to use UASs continues (e.g., the Defense Advanced Research Project Agency is now funding development of nano-UASs). The U.S. Army Roadmap for UAS 2010 – 2035 (2009) predicts that deploying SUAS at company and platoon levels would increase UAS-related training requirements by 800%.

Within the SUAS operational environment, there are a number of factors that create complexity and, consequently, bring about training requirements over and above training a Soldier to operate the system (Durlach 2007). The effective utilization of SUAS requires coordination between the operator and others. This coordination includes consideration of additional assets (e.g., other military air elements), an understanding of commander's intent and planning, preparation and coordination to carry out that intent. Little attention has been paid thus far to the collective aspects of training for employment of SUAS. Research is required to determine where unanticipated issues may arise in the collective employment of SUAS, and how these can be addressed, through dedicated training on how to avoid these issues, and technological support to help overcome them. The current project created a simulation environment as a mechanism for providing research on the collective training issues that will arise as lower and lower echelons are assigned SUASs.

Future training must facilitate learning of skills necessary for the operation of SUAS, competencies unique to leaders with SUAS assets under their control, and leader and operator coordination and information sharing. For example, operators must acquire skills related to terrain analysis, monitoring and target identification, while leaders require skills related to delegation and mission planning. Leaders must assess situational factors that may change minute to minute, and promote overall mission goals through the use of the SUAS (Pavlas et al., 2009). On top of these individual requirements, operators and leaders must also learn to coordinate with each other, share appropriate information, and communicate effectively. While the individual and collective elements are difficult enough to train, the nature of current SUAS capabilities (or lack thereof) does not help. For example, the operator and the leader are almost always distributed with no technical support to create a common operating picture. The operator is often required to relate an interpretation of the visual information received from the SUAS feed to the leader verbally, over a non-dedicated radio net. The leader must then make decisions based on the operator's interpretation. Additionally, because leaders have so many other duties, they usually have little if any training or expert knowledge of the system capability or the challenges, both environmental and operational, which may influence system performance.

Further complicating the interaction and coordination, leaders and operators often do not have adequate insight into what the other knows and needs to know. For example, leaders must consider other variables that the operator may have no knowledge of (e.g., Soldier ground movement within an adjacent area of operation) and leaders, in turn, may not understand all of the constraints on operating the SUAS. As a result, this coordination requires a great deal of communication, cooperation, and information sharing that goes beyond each individual's task skills or knowledge (De Visser, et al., 2008; LeGoullon, et al., 2010).

Our simulation environment for investigating issues for this domain allows for conducting a near platoon-sized exercise in a virtual world. In addition to this world, the SUAS operator has a simulated control station for the aerial vehicle, and the nominal leader has a command and control station. Both of these stations are configurable, such that one could test the effectiveness of different (simulated) technical solutions to ameliorate coordination problems, by manipulating both the information presented at each station and the information that can be passed between them. The resulting simulation and an initial investigation of its usability is described below. While future research will ideally delve into more complex issues described in the preceding paragraphs, this investigation was intended to test the practicality and effectiveness of using such a complex environment (e.g., multiple interfaces and functionality requiring multitasking). We first describe the components of research simulation, and then describe the details of our initial experiment.

Research Simulation Environment

Operator Training Simulation: Initial Research

Through collaboration with the Institute for Simulation and Training (IST) at the University of Central Florida and, later, Research Network Inc. (RNI), the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) began the investigation of simulation-based training in UAS with the development of a research platform that would enable the testing and development of simulation-based training exercises and performance measures. The goal of this research was to establish appropriate training and measurement standards for SUAS operators and commanders. The first step in this process was to create a simulated operator control unit (OCU) for SUAS operators, which was completed in prior research (Billings & Durlach, 2008; Durlach, Neumann, & Billings, 2008).

Simulated SUAS

The Simulated SUAS (SSUAS) is loosely based on a prototype Micro-Unmanned Aerial Vehicle (t-MAV) developed under the Defense Analysis Research Project Agency's MAV Technology Demonstration. The SSUAS is similar to the t-MAV (see Figure 1), incorporating a ducted-fan vertical lift design with the ability to hover, rotate, and travel at an airspeed of up to six knots under manual control and over 25 knots under waypoint navigation. Flight models were developed that allow the simulated SUAS to mimic some of the inertial properties of the t-MAV. The simulated SUAS has two cameras, one forward facing and one downward facing. The simulated SUAS is configurable so that certain aspects of the simulated SUAS can be

manipulated to investigate different aspects of performance. For example, the cameras can be configured to zoom, pan, or remain fixed.

Figure 1. Simulated SUAS in simulated environment used with the simulated OCU and subsequent research platform expansion.

Operator Control Unit

The simulated operator control unit (SimOCU) allows a human to control the SSUAS. The SimOCU display includes an altimeter, camera views with a heading tape, a flight controls, options for developing flight paths, and an overhead map showing the location of the simulated

SUAS within a simulated military operations on urban terrain (MOUT)or urban operations (UO) environment (See Figure 2). Furthermore, the icons on a tool bar along the top of the display allow for operators to program automated flight paths, preset waypoints, and launch or interrupt the SSUAS along a predetermined, automated path. Like the simulated SUAS, the SimOCU is reconfigurable as well, enabling for further investigation into operator performance. For example, the SimOCU can be configured to use a computer mouse or a game controller to operate the simulated SUAS. The SimOCU is written in Linux using freely available software (Open Scene Graph for rendering and OpenAL for audio) and requires no additional licenses. The SSUAS and a base station (i.e., a simulated military vehicle where the operator is supposed to be within the simulated environment during operation of the SUAS) are transmitted using the Distributed Interactive Simulation (DIS) protocol so that both can be displayed in other systems, enabling networking and sharing of information or output by multiple systems. Any modem PC and video card can satisfactorily run the SimOCU.

In addition to the SimOCU, synthetic environments for the simulated SUAS to operate within were created. Specifically, environments were created based on two Army MOUT or UO training sites, simulating small towns with different features used in live training exercises. While the overhead map feature requires an additional image file, any OpenFlight database can be loaded and a map or an aerial view can be used. For the display and routing of various types of routes and dismounted personnel, other entities can be imported through DIS. For example, we successfully interoperated with OneSAF Testbed Baseline v2.5 in order to populate the environment with entities.

Prior Research Findings

A full account of the research using the SimOCU can be found in the literature (Billings & Durlach, 2008; in press; Durlach, Neumann, & Billings, 2008). These studies concentrated on two types of missions: flight skills missions, and reconnaissance missions. Over three studies, participants were given initial introductory training on how to use the SimOCU and then were asked to perform a series of missions involving either navigation of the environment or detecting and photographing enemy targets. In all missions, participants controlled the SSUAS through the SimOCU. Different SimOCU configurations were used based on the goals of the individual studies, and the sensitivity of various measures (e.g., number of collisions, number of targets, time to complete mission) were examined based on performance effects of these configurations. The results of these studies using the SimOCU suggested the most sensitive performance measures for training operators were temporal measures (i.e., time to complete mission). This implies that standards-based training should incorporate temporal measures with other crucial but less sensitive performance indicators (e.g., number of targets detected).

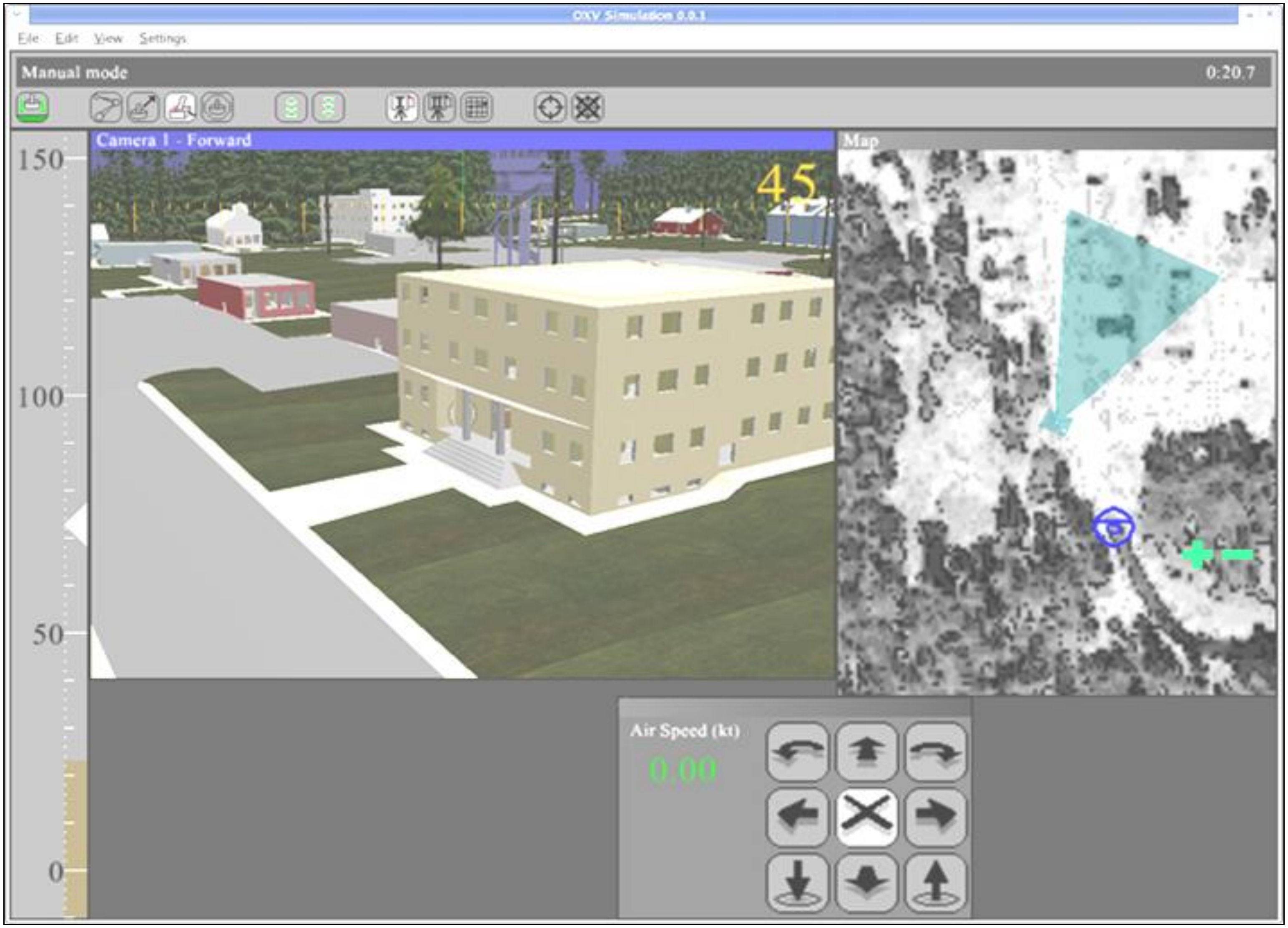

Figure 2. Example of SimOCU interface.

Team-Level Mission Simulation

While the importance of training operators of small unmanned aerial systems (SUASs) has been embraced by military and training professionals, less attention has been devoted to how to train the effective and efficient coordination of SUASs within teams. At a minimum, the operator will need to coordinate with either a robotics noncommissioned officer (NCO) or team leader. These leaders will require training on how to plan missions that integrate SUAS, how to take into account air space and frequency management, and how to communicate commander's intent regarding the SUAS asset. To that end, the leader, operator, and other unit Soldiers must be able to communicate, coordinate, and share a common picture of the task, equipment, and other team or squad members. To address these emerging needs, we added new components to the original simulation environment: a command-and-control node (C2Node), created by IST, and a virtual environment for dismounted infantry missions with the simulated SUAS (GDIS or Game Distributed Interactive System), developed by Research Network Inc (RNI). The original components were also modified to accommodate communication between the C2Node and the SimOCU.

Specifically, following the initial operator research, the research platform was expanded to include three interacting components referred to in the introduction: 1) GDIS: a virtual immersive environment that replicates one of the synthetic MOUT sites and can be populated with human-controlled avatars and semi-intelligent computer generated forces (nonplayer characters or NPCs), 2) C2Node: a command and control node enabling communications between the commander and SSUAS operator, and 3) the modified SimOCU. Each platform element is run on a separate computer, which means that a minimum of three networked computers are needed to successfully run all simulation components simultaneously. Each of the components is briefly described next.

C2Node

The C2Node simulates elements of command and control systems such as Force XXI Battle Command Brigade and Below (FBCB2). This component provides a way for a leader to practice SUAS information management and decision making in a simulated environment. The C2Node is almost fully reconfigurable and consists of a number of optional features including an interactive map, blue force tracking, annotation, a window where streaming video or pictures are received, text windows for sending and receiving information, and menus for mission planning (see Figure 3). Options available to reconfigure include no imagery, still pictures only, or streaming video; text versus voice communication; and options for the map to display blue forces (i.e., friendly forces) or not. In fact, because this system is reconfigurable across several variables, one of the main benefits of this system is that it allows the researcher to limit or expand the information available to the leader in order to assess the impact on mission coordination. For example, the impact on mission performance of the leader having no imagery, still images, or streaming video could be investigated. C2Node features also allow the user to plan missions with routes, no fly zones, and flagged entities. Again, dependent on selected configuration, it may be possible to send these plans to the SimOCU operator. For research purposes, the C2Node logs user interaction data, recording all information exchanged between the SimOCU and the C2Node.

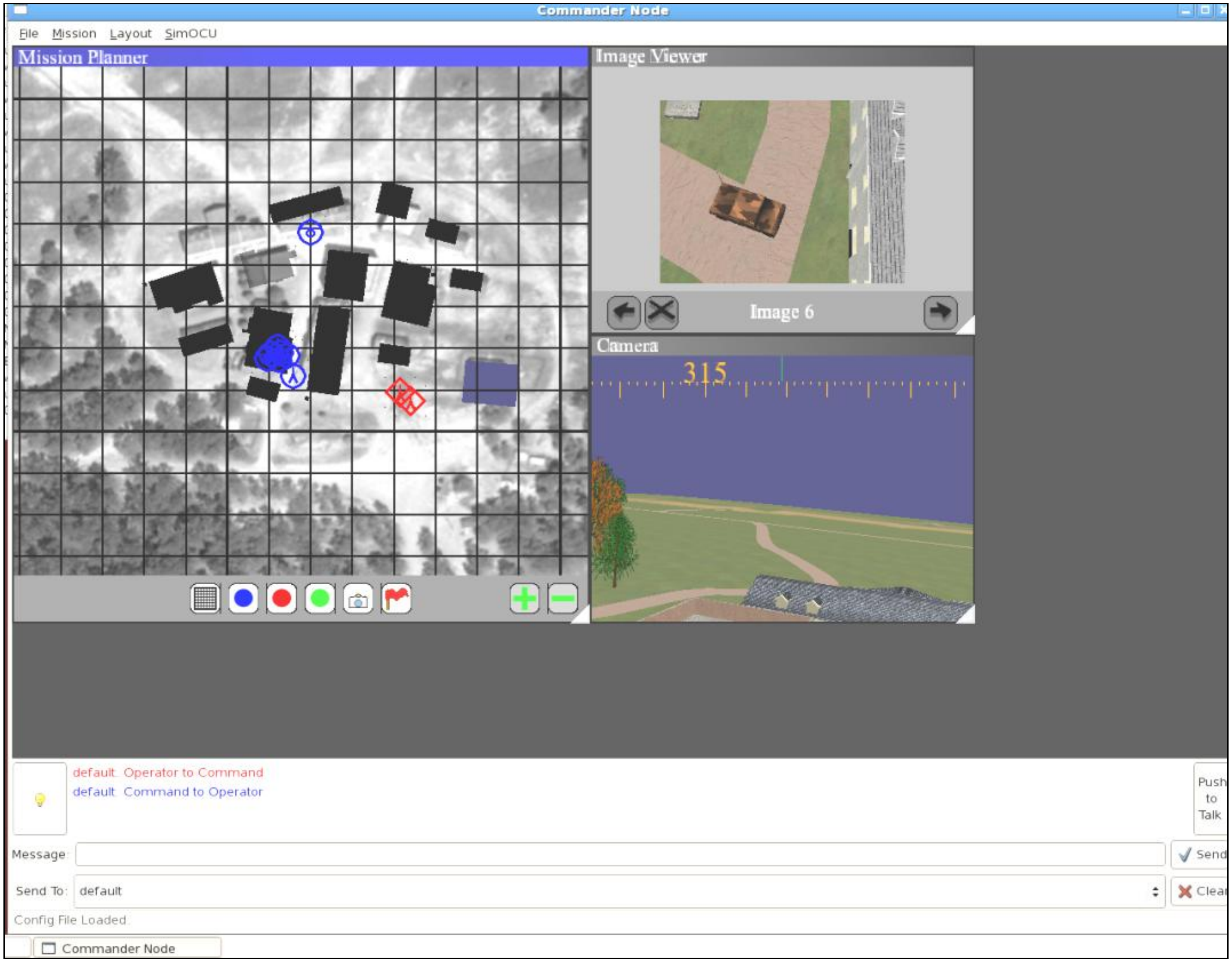

Figure 3. C2Node interface.

Modified SimOCU

The SimOCU was upgraded with additional features to allow communication with the C2Node operator, including the exchange of artifacts (e.g., pictures, routes) with the C2Node. For example, the SimOCU operator can send and receive text messages, pictures, and mission plans with the C2Node. The SimOCU is still reconfigurable and, like the C2Node, logs data in the form of a text file.

GDIS Virtual Environment

GDIS is an immersive virtual environment, similar to a first-person shooter video game. GDIS was tailored by RNI to interact with the C2Node and SimOCU, but it can also function independently (Barnett & Taylor, 2010). GDIS allows for the expansion of the dyad (i.e., leader and OCU operator) to include other characters, including Soldiers, enemy, and bystanders (See Figure 5). When networked with the C2Node and the SimOCU, a player using GDIS is able to observe and be observed by the SUAS. GDIS includes functionality that allows multiple distributed human players to control avatars, which can move, shoot, emote, and communicate with other players. The GDIS system contains substantial artificial intelligence (AI) elements as well. The AI in particular allows for multi-person scenarios with fewer human operators. This allows for platoon-sized missions and the integration of the employment of the SSUAS into those missions. Mission action is supported by experimenters and the AI-controlled NPCs. For example, an operator-in-training can use the SimOCU to fly a SUAS through the virtual environment to detect IEDs in relation to friendly forces in the environment. When these targets are detected, the operator can then relay this information to the commander at the C2node. Based on this information, the commander can communicate changes in mission plans or routes to the human players in GDIS or can use a menu system to re-route AI-based NPCs. Thus, the three different components of the research platform can work together to investigate various aspects of team performance when robotic assets are used.

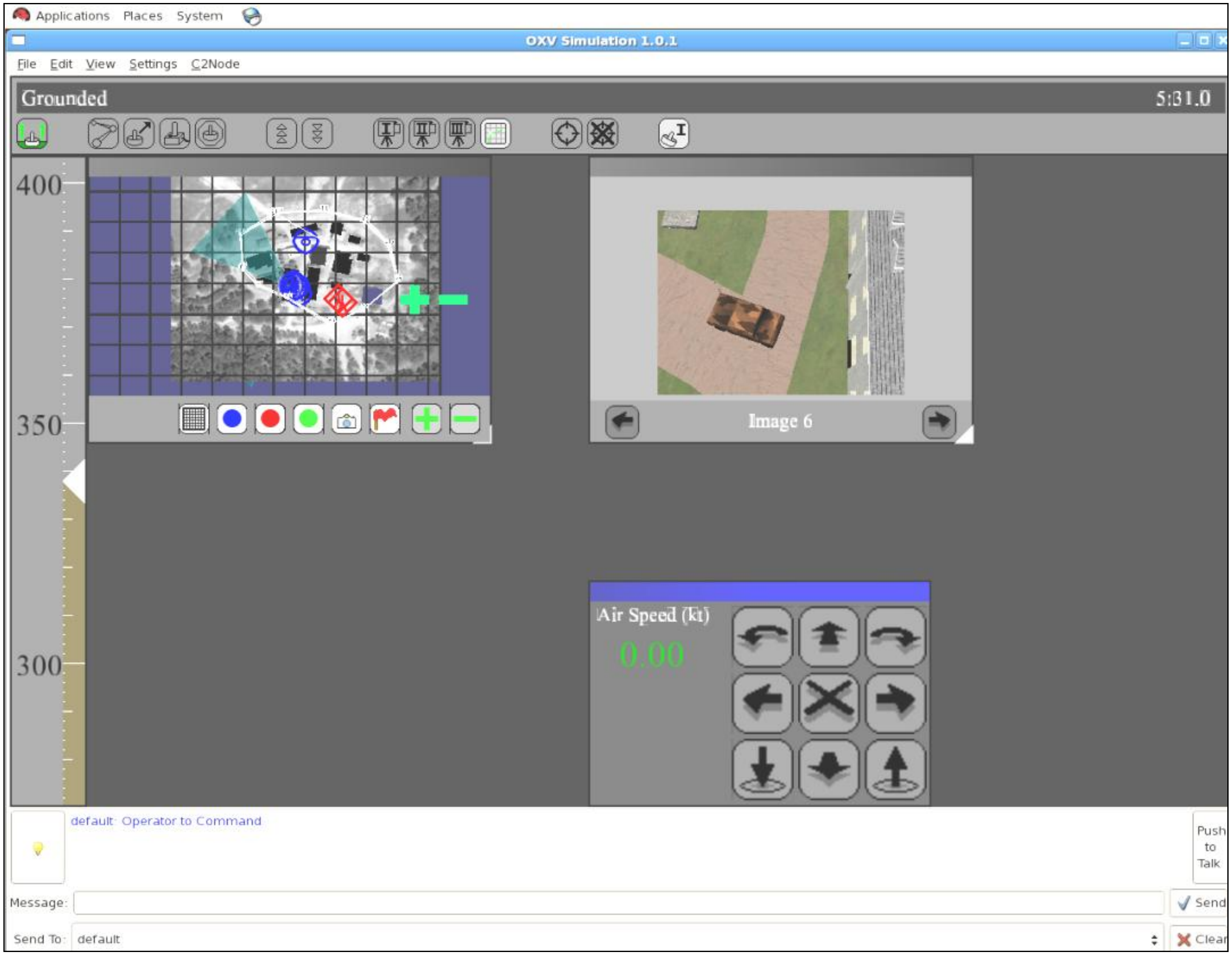

Figure 4. Modified SimOCU interface.

Authoring tools in GDIS allow an experimenter to author specific scenarios as well as change aspects of scenarios during game play. Menu-based authoring capabilities are included in GDIS, which allow for scenario generation functions, including mission planning, route generation, route assignments, insertion of objects and vehicles, and the ability to 'take over' a non-player character (NPC) or switch perspectives within game play. For example, through point and click menus, scenario authors can create and insert NPCs with a number of characteristics, including team membership, weaponry, competency (i.e., novice, expert fighter), and rules of engagement (ROEs). Routes can also be created through simple menus using waypoints. NPCs can be assigned to routes and specific instructions can be associated with any waypoint, to control their behavior. For example, a waypoint may include the instruction for the NPC to wait at that point for a specified amount of time or until some other specific event occurs (e.g., a team member reaches some other waypoint). Thus, NPC behaviors can be made contingent on other events or can be triggered by events in the environment, such as a nearby explosion or a decrease in health status of another NPC or team member. For example, if an improvised explosive device (IED) explodes a NPC team's mission might change from defensive to offensive. These if/then contingencies are specified through the menu-based authoring system in the same manner as the waypoint-associated options (see Figure 6 for an example of menu driven generation).

In addition to controlling individual NPC behaviors, the menus also contain options for team level behaviors, which are designed to be conducted by NPCs in a coordinated way without individually scripting NPCs (e.g., building search). GDIS users also have the option of taking control of NPCs during actual game play, meaning they can manually control their behavior for periods of time as they see fit and then return the NPC to autonomous mode.

GDIS has been designed with flexibility and interoperability in mind. GDIS SimBridge has been designed to allow interaction with other simulation or game platforms and to leverage new technologies easily as they become available. Currently, GDIS interfaces with the HL2 engine Mod Type and the GameBryo engine (Source Type).

Integration of Research Platform Components

The simulation environment was designed to enable realistic missions (e.g., platoon to enter town and occupy a building) in order to identify team training requirements and to investigate how team coordination is affected by the functionality provided at the C2Node and SimOCU. This information can then be used to determine how to design collective training, as well as the nature of the tools that would optimally support coordination. Before such research can be initiated, however, we wanted to determine how much of the functionality, available within the expanded research platform, could be managed and utilized by a participant-commander using both the C2Node and GDIS simultaneously. That is, we wanted to make sure that a person playing the role of a platoon leader could handle the workload of controlling an avatar in GDIS and operating the C2Node at the same time.

Figure 5. GDIS environment with NPCs and the simulated SUAS.

Figure 6. GDIS route menu.

Experiment

Workload

There are many real world situations where individuals are required to perform multiple tasks simultaneously; however, even when systems intended to make this easier are put into place, they can often increase workload, especially when proper training is not provided. Multi-tasking can often lead to decrements in performance, feelings of being overwhelmed, or neglect of some of the tasks. This is due in large part to individual characteristics and the limited capacity of working memory in general (Mayer, 2001). Thus, SUASs, intended to provide teams with additional information, may not necessarily result in improved performance if managing the employment of the system adds too much to workload.

An increase in workload in general has been found to change the way that individuals and team members make decisions. For example, Drabek and Haas (1969) found that team members switched from semi-autonomous decision making to more consultative decision-making as workload increased. In this experiment, team members showed a need for confirmation or input from others when making decisions under high stress, whereas, they were able to make more independent decisions when under low stress. Furthermore, results showed that communication changed under periods of high stress. Requests for information by lower ranking team members were directed primarily to higher ranking team members as workload increased. Team members also sought to communicate more, including seeking alternative ways of overcoming the limitations of structured communication systems used during lower rates of workload. More recent research has provided further support to Drabek and Haas' (1969) findings such that increased workload often leads to tendencies to conform to the decisions of the leader and/or the majority and a centralization of power/influence by leaders (De Grada, Kruglanski, Mannetti Pierro, 1999; Kruglanski & Webster 1996; Pierro, Mannetti, De Grada, Livi, & Kruglanski, 2004). However, the primary way that workload has been found to impact performance is from errors that result from user difficulty in gathering and selecting critical information and decision making accuracy (Kawano, Fujiie, Ujita, Kubota, Yoshimura, & Ohtsuka, 1991).

There is also a great deal of research that illustrates the negative impacts of workload with regards to new technology and operators. For example, research has shown that fewer participants finished missions using unmanned ground vehicles or performed effectively when presented with the opportunity to use multiple sensors (e.g., Rehfeld, Jentsch, Curtis, & Fincannon, 2005) or UASs (e.g., Dixon, Wickens, & Chang, 2003) to gather more information when compared with participants who only used a single source. This supports the adage that more is not always better when it comes to the use of new technology to gather, process, and share information.

As a result, our initial research effort with the expanded platform focused on issues of workload. The experiment was designed to evaluate the capacity of individuals to operate their avatar in GDIS and use the capabilities of the C2Node at the same time, with varying degrees of imposed workload. The C2Node has been designed so that the experimenter can manipulate its functionality as well as control the amount of information channeled by each function. We used some of these capabilities to determine the level of C2Node functionality and information an

individual could deal with, while still adequately conducting tasks in GDIS. We measured both perceived workload and performance during low and high workload conditions.

Usability & Utility

Because this was the first research project using the integrated simulation, we also investigated usability. A training system can only be effective if it is relatively easy to use. The trainee should be thinking about what is happening in the training scenario and how to successfully complete it, not the knobology of the user-interface. Usability of training simulations and research platforms must be systematically evaluated so that they are both functional and easy to use (Nielsen, 1994). The system interface, functionality, and artifacts should be evaluated to ensure that they can be used easily, effectively, and satisfactorily by users performing specific tasks in specific environments (Shackel, 1991). While there are a number of available methodologies for evaluating the usability of a system, one popular and easily administered method of usability evaluation is the user reactions survey. To that end, a user survey was designed to target user reactions and evaluations of user interactions with both the GDIS and C2Node systems. Participants were able to give their reactions and perceptions of ease of use for both systems. These reactions, reported below, can inform future iterations of this research platform, as well as the design of training using the different configurations available. To achieve this goal, reactions to both the interface and the functionality of GDIS and the C2Node were evaluated to ensure that these systems can be used by the targeted population and that the required functions are present. Data consisted of surveys (e.g., written questions regarding ease of use which were rated on a five point Likert scale) based on standard usability questions presented in the literature (Nielsen, 1994; Rossen & Carroll, 2002).

Research Objectives

As stated, the main objective was to evaluate whether participants could operate the C2Node and GDIS simultaneously. Participants performed four different search and identification tasks, in which task requirements were varied for a total of four practice trials. Two versions of the GDIS (low vs. high demand) and two versions of the C2node task (low vs. high demand) were crossed, so that each participant performed each of four different levels of task demand over four trials.

Baseline (low workload) tasks were developed for GDIS and the C2Node, along with workload tasks for each. The baseline tasks were designed to utilize a portion of the functionality of each system that seemed likely to be included in future training and experimentation (e.g., search and identification tasks). The goals were to determine 1) if users could effectively complete baseline tasks using both system components simultaneously, 2) if added workload kept them from performing baseline tasks effectively using both system components simultaneously, and 3) if users found both systems usable and had positive reactions overall. The mission scenario used was not tactical because of the available sample (i.e., college students); however it did include GDIS and C2Node operations likely to be required in more militarily relevant scenarios.

Method

Participants

Data were collected using a student population recruited from the local university. The goal sample size was 32 for a within group manipulation of both trial and workload (i.e., each participant performed in 4 trials and experienced 4 levels of workload). Although the sample size is relatively small, the within-subjects design increases the power because each participant provides 4 data points by experiencing each workload condition across the four trials. Specifically, each workload condition had 32 participants because each participant experienced each level of workload and each participant had four trials. Furthermore, tests of Normality specifically targeting small sample sizes showed a normal distribution, supporting the inclusion of parametric testing. Specifically, the Shapiro-Wilk Test, which is more appropriate for small sample sizes (< 50 samples), was used to test as our numerical means of assessing normality (i.e., with this specific test, if the significance value is greater than 0.05, then the data is normal). See Table 1 for a list of significance values. As can be seen, the significance levels for all four trials are greater than 0.05, indicating a normal distribution.

Table1

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Trial	Statistic	df	Sig.	Statistic	df	Sig.
Overall Score	1	.289	8	.047	.839	8	.074
	2	.197	8	.200*	.908	8	.342
	3	.190	8	.200*	.909	8	.347
	4	.215	8	.200*	.928	8	.494

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

No specific qualifications were required other than those participants be over 18 years of age and have normal or corrected vision. Participants received extra credit, with the amounts

based on length of their participation in the research (e.g., full participation warranted two extra credit points).

Search and Identification Scenarios

The scenarios required participants to use both the C2Node and GDIS simultaneously. Participants were given instructions that they were in command of US troops who are part of a platoon that has recently liberated a small village in an unnamed country. They are told that the Red Cross has sent medics to care for refugees and that there are Soldiers in the area providing security as well as questioning refugees. However, with all the different organizations entering and leaving the area, there is little information being sent to headquarters on the number and location of Soldiers, medics, and refugees. Therefore, the task was to identify the number and location of Soldiers, medics, and refugees within the liberated village. Also, due to concern over lingering enemy forces, the participants were told that they will receive intelligence (i.e., information or pictures) from a micro-unmanned aerial vehicle operated by a Soldier under their command and that they must report the Intel (e.g., identify targets in pictures) to Headquarters.

Under this premise, participants were asked to perform two basic tasks, one within GDIS and one within C2Node, simultaneously. Within GDIS, participants were asked to navigate their avatar through buildings circled on maps (different buildings for each trial) and identify Soldiers, medics, and refugees within buildings, logging these on a paper form. Within the C2Node, participants were asked to identify the presence or absence of vehicles or people (i.e., Humvees, none, unknowns, and Soldiers) for Headquarters, based on pictures received on the C2Node interface from the SUAS (which were sent by the experimenter who was utilizing the SimOCU). Participants were asked to identify different items per trial, by replying ‘y’ or ‘n’ in the text box within the C2Node. Participant responses were captured by the system through the texting capabilities of the C2Node and SimOCU. These yes or no answers to item detection served as one of the performance measures. The identification of the number of Soldiers, medics, and refugees entered on the paper form was another. These performance measures were used with the time on task to calculate an overall performance score.

To create the high workload demand conditions, an additional task was added onto each system. The C2Node extra task consisted of identifying the location of the SUAS using the interactive grid map and then reporting the first four coordinates of its location using the text feature within C2Node. Headquarters (i.e., the experimenter) prompted participants for the location of the SUAS through the text feature of the C2Node. The GDIS extra task consisted of identifying the position of a doctor, played by a NPC following a pre-scripted route. Headquarters (i.e., the experimenter) prompted the participants for the location of the doctor through the text feature of the C2Node. To successfully perform this extra task, participants had to refer to two different area maps. First, participants pulled up an interactive map in GDIS and found the location of the doctor. While the doctor’s location showed up on this map, the building numbers that needed to be reported to Headquarters did not. Therefore, participants used a second paper map to identify the specific building number that the doctor was closest to. They reported the location using the text function in C2Node. As a result, over the 4 trials, participants experienced 4 levels of workload: 1) low GDIS workload, low C2Node workload (i.e., only the baseline tasks), 2) high GDIS workload, low C2node workload, 3) low GDIS workload, high

C2Node workload, and 4) high GDIS workload, high C2Node workload. All communication sent and received through the C2Node texting capability was captured and time stamped for analysis.

Materials

Paper-and-pencil or computer based surveys were given pre and post- training.

Demographics questionnaire

The demographics questionnaire consisted of questions regarding the age, gender, and student status of the individual (see Appendix B). Also included were a series of questions to get an indication of the participant's ability with computers and first-person shooter games. This information was used in the analyses to test for the effects of skill level workload and performance within each component, as well as to compare different groups of participants based on computer and video game use.

Spatial ability measure: Cube Comparison Test. A test was also given to measure spatial orientation (i.e., the ability to accurately estimate changes in the orientation of an object; Velez, Silver, & Tremaine, 2005). The Cube Comparison Test (CCT) measures Spatial Orientation by presenting pairs of cubes. Participants are asked to determine if one cube represents a rotated version of the other cube. The test consists of two 3-minute sections with 21 questions each. The higher the CCT score, the higher the individual's spatial ability.

Measure of workload: NASA-TLX

A measure of workload was also used in this research to determine the perceived workload of participants following each trial. Specifically, participants were given a computer-based version of a commonly used workload survey (i.e., the NASA Task Load Index or NASA-TLX) to measure their perceptions of workload on six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration. Hart and Staveland's (1988) NASA-TLX method assesses workload on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales. Participants are then given weighted scores based on pair-wise comparisons performed on the six dimensions. This measure was presented before training and then again following each trial. The participants were asked to rate the workload of the condition immediately preceding the administration of the survey. The higher the NASA-TLX score, the higher the individual's perceived workload.

Usability survey

A usability survey was given to participants at the end of the experiment. The surveys were based on established usability questions of reactions and interactions with systems (Neilsen, 1997) but were crafted specifically for each system within this research project based on their functionality and demands on users. The GDIS Usability Survey (see Appendix C) and the C2Node Usability Survey (see Appendix D) consisted of 15 questions, including a 7-part

reaction question. Participants were asked to rank their agreement with terms or statements based on a 9-point anchored Likert scale.

Procedure

Participants were asked to come to the research location and were briefed about the specific nature of the research, the requirements for participation and tasks, and any risks that may be involved (e.g., simulation sickness). If they agreed to participate, they then signed the informed consent form provided. The participants were then given training sequentially on the systems based on a protocol of guided practice. This consisted of PowerPoint slides for both the GDIS and C2Node systems. For GDIS, these slides explained how to move, identify items, receive pictures, and send texts. After participants read through these initial GDIS slides, they were required to perform three tasks within GDIS using skills necessary for the experimental trials. They then performed analogous training for the C2Node. Most participants were able to perform adequately; two participants were excused because they could not learn to use GDIS in the time allotted.

Following training, participants were asked to complete a demographics questionnaire (Appendix B), a spatial abilities test (the cube comparison test), and baseline measures of perceived workload (NASA-TLX). Once the initial training and pre-test surveys were completed, participants were given instructions for the experimental task. Instructions and procedures were scripted to ensure uniform presentation across researchers (See Appendix E). Participants were then asked to perform across 4 training trials. Each trial lasted between 5 and 15 minutes (dependent on participant performance) and presented conditions of low and high workload described above. Performance measures, along with the NASA-TLX measure of perceived workload, were collected after each trial. Performance scores consisted of a composite score based on performance in the C2Node (i.e., number of items identified correctly), performance in the GDIS system (e.g., number of Soldiers, medics, and civilians identified correctly), and the time to complete these tasks using a speed to accuracy equation (time allowed x number of correct responses)/time to complete; following Zandin, 2001). The overall performance score (i.e., higher scores indicated better performance) and perceived workload scores (i.e., higher scores indicate higher perceived workload) were the repeated measures.

Design

The experiment was a within subject design, where each participant had 4 trials and experienced all levels of workload. The order in which the workload was presented was randomly assigned so that the order of presentation varied. Specifically, some participant trials increased in workload sequentially (i.e., trial 1 had the lowest workload and trial 4 had the highest). Other participants trials decreased in workload (i.e., trial 1 had the highest workload and trial 4 had the lowest). While other participant trials were varied randomly (trial 1 may have had high workload for the C2Node but not the GDIS task, while trial 4 had high workload for GDIS, but not for C2Node). However, each participant had 4 training trials and experienced all 4 levels of workload.

Results & Discussion

Data Analysis

Analyses of Covariance (ANCOVAs) were conducted for performance over the four trials (one-way repeated measure) as well as for workload (GDIS x C2Node workload), where the dependent variable was the overall performance of participants on the task described above and the covariates were video game experience and spatial ability. An additional ANCOVA was performed for perceived workload scores based on task loading (i.e., workload). Post-hoc tests (e.g., pairwise comparisons, Bonferroni corrections) were also performed when significant relationships were found to identify the source of significant differences.

Demographics & Spatial Ability

Of the 32 participants in the final sample, 35% of participants were female (*n*=11) and 65% were male (*n*=21). A majority of the participants used computers daily (*n*=29), with almost everyone using computers five to 30 hours per week (*n*=25). Seventy-eight percent of participants rated their computer skills as Novice/Beginner (*n*=27), with no one claiming they were an expert. A majority of participants had previous remote control experience (*n*=25) and owned a video game system (*n*=25). While most participants considered themselves novice when it came to computer skills, only 13% rated their video game skills as Novice/Beginner (*n*=4). The majority of participants rated their video game skills as intermediate (*n*=15) or expert (*n*=13).

Demographic data and spatial ability were examined for correlations with the dependent variables. Specifically, it was found that questions related to video game experience and spatial ability scores were positively associated with overall performance. In particular, responses on a question about number of hours of game-play per week were significantly correlated with overall performance, $r = .71$, $n = 32$, $p < .05$. Scores on the Cube Comparison Test, which tested spatial ability and ranged from -2 to 36 ($\mu = 16.19$, $SD = 9.51$), indicated a significant positive relationship between spatial ability and performance, $r = .39$, $n = 32$, $p < .05$. As a result, both hours spent playing video games and the Cube Comparison Test scores were included as covariates within the overall analyses.

Performance on Multiple Systems: Trial Order

Figure 7 shows mean overall performance as a function of trial (e.g., the order of training). A one-way repeated measures ANCOVA conducted on these data, with video game hours and Cube Comparison Test scores as covariates, indicated a significant effect of trial, $F(3, 29) = 6.72$, $p < .00$, $\eta_p^2 = .19$. Post hoc comparisons with Bonferroni correction indicated that trials one and two failed to differ, and trials three and four failed to differ; however, the first and second trial scores were significantly lower than scores on the third and fourth trials (both $p < .00$). Further analysis showed a significant drop in time to complete each trial, $F(3, 29) = 8.25$, $p < .00$, $\eta_p^2 = .47$, with mean times ranging from 7.54 (trial 1) to 4.56 (trial 4). Figure 8 illustrates an increase in speed across trials 1 to 4 and Figure 9 shows that there was no detectable decrease in accuracy across those trials.

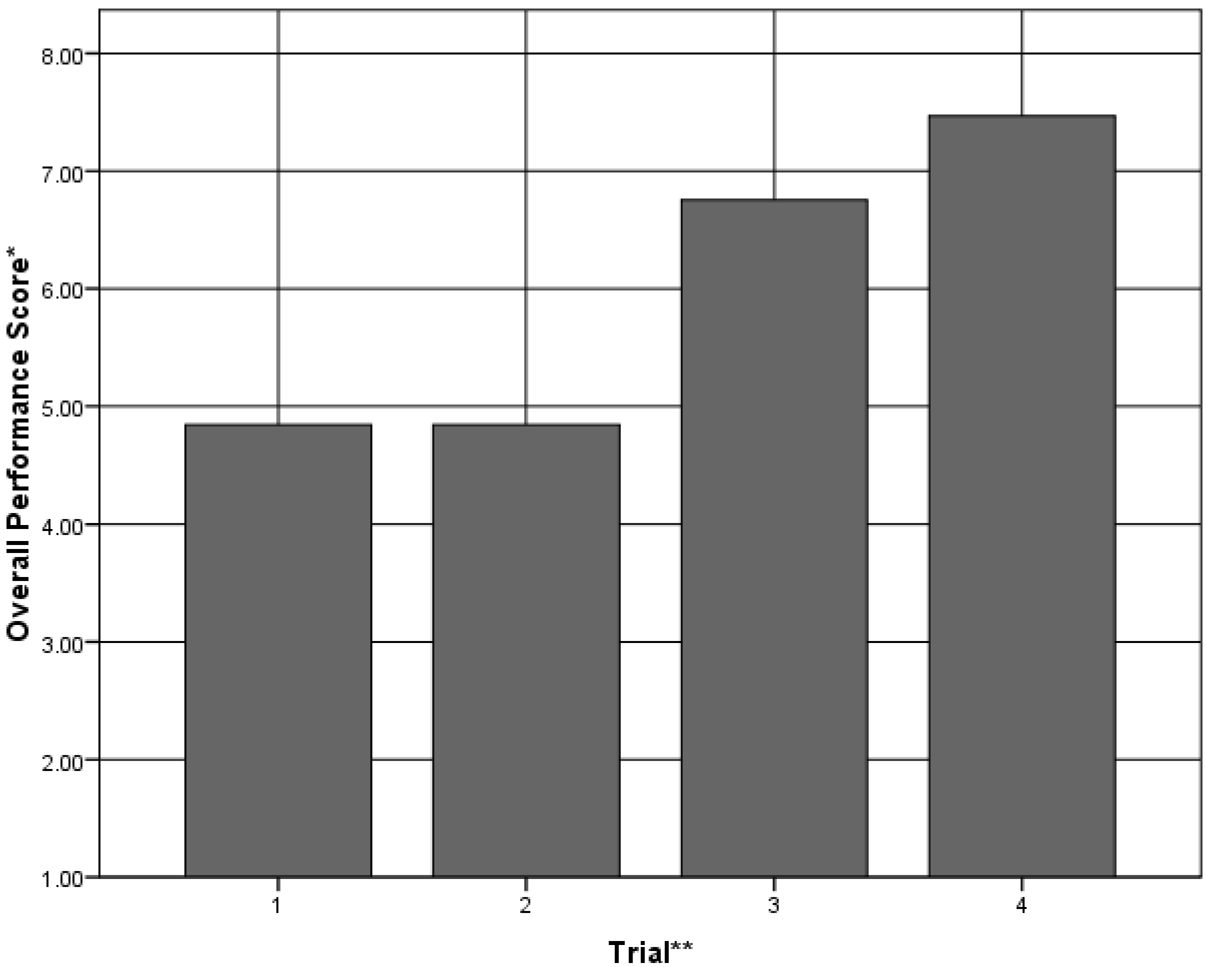

Figure 7. Mean overall performance scores by trial.

*Overall Performance: the higher the score, the better the performance
**Trial number refers to the order of presentation (i.e., trial 1 was the first trial)

.

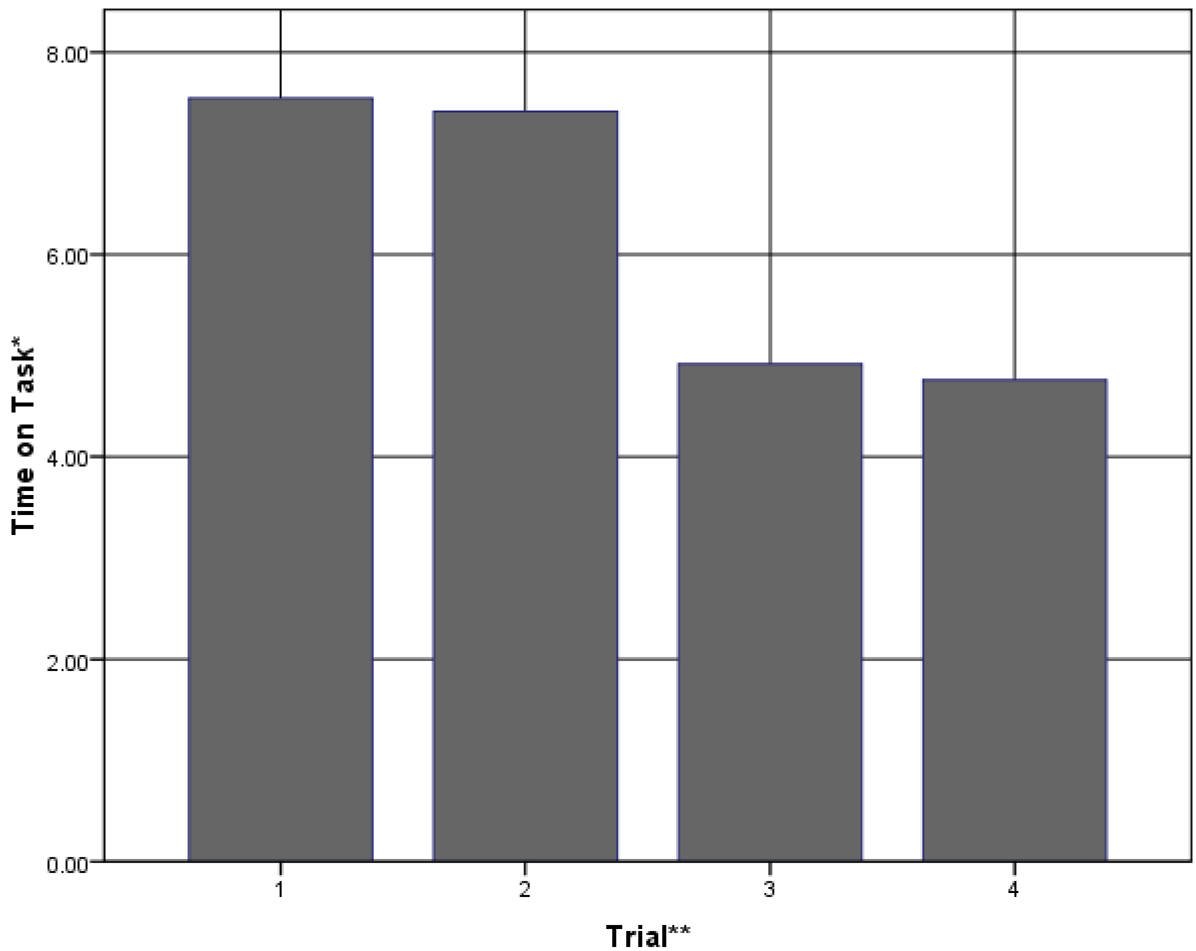

Figure 8. Time on task by trial.

*Time on task refers to the time to complete each trial
**Trial number refers to the order of presentation (i.e., trial 1 was the first trial)

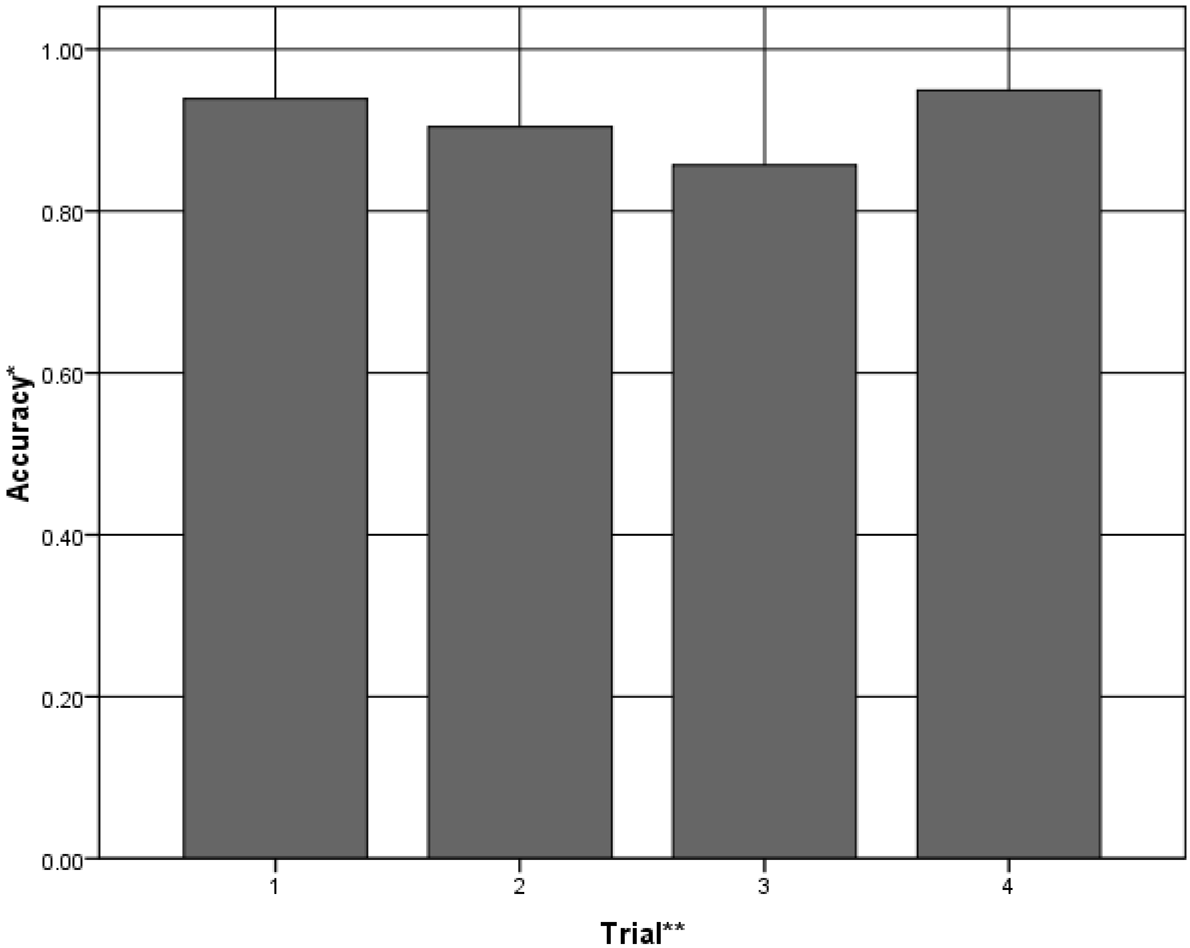

Figure 9. Mean percentage correct by trial.

*Accuracy refers to percentage correct
**Trial number refers to the order of presentation (i.e., trial 1 was the first trial)

Performance on Multiple Systems: Workload Conditions

Table 2 shows mean performance scores for the four task demand conditions. A 2 x 2 ANCOVA with GDIS workload (high vs. low) and C2Node workload (high vs. low) as within-subject factors, and Cube Comparison Test and video game hours as the covariates, revealed a main effect of workload in GDIS, $F(1, 29) = 11.62$, $p < .001$, $\eta_p^2 = .29$, and C2Node, $F(1, 29) = 12.14$, $p < .001$, $\eta_p^2 = .30$. Based on these differences, post hoc comparisons were made between high and low task loading for both GDIS and C2Node. Results indicated a significant difference between performance on high and low workload for GDIS (Bonferroni corrected $p < .001$), but no difference between high and low workload for the C2Node.

Table 2

Mean Performance Scores and Standard Deviations for Workload Conditions

		GDIS	
		Low	High
C2node	Low	6.7 (3.1)	5.3(2.6)
	High	6.4(2.5)	5.5(2.2)

These main effects were not qualified by an interaction between GDIS and C2Node workload, $F(1, 29) = 0.25$, $p < .62$. There was a significant interaction between C2Node workload and spatial ability as measured by the Cube Comparison Test (CCT) scores, $F(1, 29) = 16.77$, $p < .001$, $\eta_p^2 = .37$. Correlations showed that the CCT was highly correlated with low C2Node conditions but not with high C2Node conditions. In other words, if there was a high level of workload within the C2Node, spatial ability failed to correlate with performance; however, if workload within the C2node was low, spatial ability did correlate with performance. Because the GDIS task had a spatial component (navigating around the virtual environment), but the C2Node task did not, this pattern suggests that spatial ability had a detectable impact on overall performance only when the C2Node tasks (nonspatial) required relatively little effort, allowing them to concentrate on the spatially oriented GDIS task. This may have led to an advantage in overall performance for people who had higher spatial ability. Based on this, scores on each task (e.g., GDIS and C2Node) were examined for their relationship to spatial ability. The findings (See Table 3) were consistent with what we found in the overall scores. That is, when GDIS and C2Node scores were examined separately, both scores were correlated with CCT only when there was low workload in the C2Node. This is to be expected since, while the scores were collected separately, the tasks were still being performed simultaneously, so the same effects would be expected on both scores.

Performance on Multiple Systems: Perceived Workload on the NASA-TLX

With regard to perceived workload as measured by the NASA-TLX, a one-way repeated measures ANCOVA using video game experience and spatial ability as covariates was conducted, which included NASA-TLX scores following initial training and then each trial. There was a significant difference, $F(4, 28) = 4.45$, $p < .05$, $\eta_p^2 = .13$. Post hoc comparisons revealed that the measure of workload taken prior to the first scenario (i.e., training workload) was significantly lower than all task conditions except for LowGDIS, LowC2Node. (*p's* < .001); but none of the other comparisons were significantly different.

Table 3

Pearson Correlation Matrix Among Workload and Cube Comparison Test Scores

	Overall Score			
	Low GDIS, Low C2Node	High GDIS, Low C2Node	Low GDIS, High C2Node	High GDIS, High C2Node
CCT Score	.42**	.59**	.14	.13
	GDIS Scores			
	Low GDIS, Low C2Node	High GDIS, Low C2Node	Low GDIS, High C2Node	High GDIS, High C2Node
CCT Score	.47**	.50**	.12	.32
	C2node Score			
	Low GDIS, Low C2Node	High GDIS, Low C2Node	Low GDIS, High C2Node	High GDIS, High C2Node
CCT Score	.52**	.44*	.03	.19

**p < 0.01

Table 4

Mean NASA-TLX Scores and Standard Deviations by Task Loadings

	Training	LoGDIS-LoC2Node	HiGDIS-LoC2Node	LoGDIS-HiC2Node	BothWL
NASA-TLX Score	36.3 (17.4)	43.0 (21.0)	49.1 (19.9)	45.1 (17.5)	45.9(19.3)

Usability

The mean usability score for all participants regarding the C2Node was 7.52 (*SD* = 1.01) out of 10 and ranged from 4.8 to 8.9. The mean usability score for all participants regarding the GDIS was 7.65 (*SD* = 1.05) out of 10 and ranged from 3.4 to 8.9. The lowest mean ratings for usability for the C2Node were for questions about whether the system was dull or stimulating (with dull being the lower end of the scale, with the mean being 5.5). The lowest ratings for usability for GDIS were for questions about whether the system was frustrating or satisfying (with frustrating being the lower end of the scale, with the mean being 6.2). There were no significant effects for spatial ability or video game use on usability scores for either system.

Discussion & Future Research

The findings suggest that participants were quickly able to master use of the C2node and GDIS systems simultaneously. Overall performance improved rapidly over trials, largely due to a decrease in time to complete, as accuracy was high throughout. While there were differences in performance based on workload, with higher workload proving more difficult, the improvement gained from repetition was larger than the effect of the workload manipulation. Furthermore, while spatial ability and video game experience did impact overall performance, spatial ability seemed to have the biggest impact when C2node was the least complex, which may mean performance was more influenced by the GDIS tasking. This first investigation was relatively simple, requiring participants to walk around the virtual environment to find and identify people and objects, and to process and send text and graphics on the C2Node. Future research should focus on more tactically realistic tasks. The present results suggest that this simulation environment is usable and can, therefore, be used to conduct research on ‘friction points’ of coordination (i.e., types or conditions of interaction where coordination between the leader (at the C2Node) and the operator (at the SimOCU) breaks down when bottlenecks occur, and how training can be designed to help ease these performance trouble spots. To that end, the software has been made available to contractors (i.e., SA Technologies, Design Interactive, Alion, Inc.) for research purposes. The reconfigurable nature of the C2Node and SimOCU can also be capitalized on to investigate how features of the technical tools provided can help or hinder mission coordination. As a result of the functionality developed and the complexity of the SUAS domain, future plans for research include team focused studies that will examine the use of both adaptive training elements (e.g., mastery-based feedback) and synthetic team members to train for complex team interaction and coordination.

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Appendix A

List of Acronyms

(Listed in alphabetical order)

AI – Artificial Intelligence
ARI – Army Research Institute
C2Node – Command and control node
CCT – Cube Comparison Test
DIS - Distributed Interactive Simulation
FBCB2 - Force XXI Battle Command Brigade and Below
GDIS - Game Distributed Interactive System
IED - Improvised Explosive Device
IST – Institute for Simulation & Training
MAV (t-MAV) - Micro-Unmanned Aerial Vehicle
MOUT – Military Operations on Urban Terrain
NASA-TLX – NASA Task Load Index
NCO – Non-Commissioned Officer
NPC – Non-Player Character
OCU – Operational Control Unit
SimOCU – Simulated Operator Control Unit
RNI – Research Network Inc.
ROE – Rules of Engagement
SUAS – Small Unmanned Aerial Systems
UAS – Unmanned Aerial Systems
UO – Urban Operations

Appendix B

Demographics Questionnaire

1. Year of birth: ___________
2. Gender:

☐ Male ☐ Female

3. Have you graduated from high school?

☐ Yes ☐ No

4. Which hand do you write with?

☐ Left ☐ Right

5. Is your vision in each eye correctable to 20/20?

☐ Yes ☐ No

6. To your knowledge, are you color blind?

☐ Yes ☐ No

7. Do you own or have access to a computer?

☐ Yes ☐ No

8. If yes, how often do you use a computer?

☐ Daily ☐ Several times a week ☐ Occasionally ☐ Never

9. Estimate how many hours per week you use a computer.

☐ Never ☐ 1-5 hrs ☐ 5-10 hrs ☐ 10-20 hrs ☐ 20-30 hrs ☐ 30-40 hrs ☐ 40 + hrs

10. How do you rate your computer skills?

☐ Novice/Beginner ☐ Intermediate ☐ Expert

11. Do you use the Internet?

☐ Yes ☐ No

12. Do you have any previous remote control (R/C) experience (including cars, boats, etc.)?

☐ Yes ☐ No

13. Do you own or use a video game system?

☐ Yes ☐ No

14. How would you rate your video game skills?

☐ Novice/Beginner ☐ Intermediate ☐ Expert

15. How often do you play video games?

☐ Daily ☐ Several times a week ☐ Occasionally ☐ Never

16. Estimate how many hours per week you play video games.

☐ Never ☐ 1-5 hrs ☐ 5-10 hrs ☐ 10-20 hrs ☐ 20-30 hrs ☐ 30-40 hrs ☐ 40 + hrs

Appendix C

GDIS Usability Survey

USABILITY QUESTIONNAIRE

Directions: Please answer the following questions as completely as possible with regards to computer application you just used (GDIS). Place a circle around the number that best represents your rating of your experience, and fill in comments and/or clarifying statements, as necessary. Write "N/A" if feature is not applicable.

1. OVERALL REACTIONS TO GDIS System — **Comments or "N/A"**

terrible — wonderful
0 1 2 3 4 5 6 7 8 9 ____________________

difficult to use — easy to use
0 1 2 3 4 5 6 7 8 9 ____________________

frustrating — satisfying
0 1 2 3 4 5 6 7 8 9 ____________________

inadequate functionality — adequate functionality
0 1 2 3 4 5 6 7 8 9 ____________________

rigid — flexible
0 1 2 3 4 5 6 7 8 9 ____________________

useless — useful
0 1 2 3 4 5 6 7 8 9 ____________________

dull — stimulating
0 1 2 3 4 5 6 7 8 9 ____________________

INTERACTIONS — **Comments or "N/A"**

2. Walking/Running
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________________

3. Changing weapons
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________________

4. Identifying hostages
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________________

UCF University of Central Florida IRB
IRB NUMBER: SBE-08-05758
IRB APPROVAL DATE: 9/19/2008
IRB EXPIRATION DATE: 8/10/2009

INTERACTIONS (continued) | **Comments or "N/A"**

5. Identifying enemies

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

6. Identifying friendly forces.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

7. Clearing buildings.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

8. Finding the way from building to building.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

9. Using map.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

10. Using the keyboard.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

11. Using the mouse.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

12. Inserting/planning waypoints.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

13. Assigning/creating teams for routes.

difficult									easy	
0	1	2	3	4	5	6	7	8	9	________

14. The system feedback on when buildings were cleared was.

confusing									clear	
0	1	2	3	4	5	6	7	8	9	________

15. Both experienced and novice user's needs were taken into consideration.

never									always	
0	1	2	3	4	5	6	7	8	9	________

Appendix D

C2Node Usability Survey

USABILITY QUESTIONNAIRE

Directions: Please answer the following questions as completely as possible with regards to computer application you just used (C2Node). Place a circle around the number that best represents your rating of your experience, and fill in comments and/or clarifying statements, as necessary. Write "N/A" if feature is not applicable.

OVERALL REACTIONS TO C2Node System — **Comments or "N/A"**

terrible — wonderful
0 1 2 3 4 5 6 7 8 9 ____________

difficult to use — easy to use
0 1 2 3 4 5 6 7 8 9 ____________

frustrating — satisfying
0 1 2 3 4 5 6 7 8 9 ____________

inadequate functionality — adequate functionality
0 1 2 3 4 5 6 7 8 9 ____________

rigid — flexible
0 1 2 3 4 5 6 7 8 9 ____________

useless — useful
0 1 2 3 4 5 6 7 8 9 ____________

dull — stimulating
0 1 2 3 4 5 6 7 8 9 ____________

INTERACTIONS — **Comments or "N/A"**

2. Texting.
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________

3. Finding positions on map grid .
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________

4. Identifying MAV position.
difficult — easy
0 1 2 3 4 5 6 7 8 9 ____________

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INTERACTIONS (continued) Comments or "N/A"

5. Sending mission plan to MAV.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

6. Using the key board and mouse.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

7. The functionality of the buttons for switching between camera views was

confusing clear

0 1 2 3 4 5 6 7 8 9 ____________________

8. The functions of the on-screen manual control buttons (on the control pad) were

confusing clear

0 1 2 3 4 5 6 7 8 9 ____________________

9. Organization of information on the video display screen was

confusing clear

0 1 2 3 4 5 6 7 8 9 ____________________

10. Current status (such as Taking off, Landing, Grounded) messages were

confusing clear

0 1 2 3 4 5 6 7 8 9 ____________________

11. Identifying entities in pictures.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

12. Inserting/planning waypoints.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

13. Inserting and formatting flags.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

14. Saving/loading mission plans.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

15. Using the voice function to communicate.

difficult easy

0 1 2 3 4 5 6 7 8 9 ____________________

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Appendix E

Experimenter's Script

Experimenter should have practice maps loaded.

Experimenter should go to confederate GDIS computer, select create server, and hit enter.

Select Spectate

Load Map (F10) and Select training exp 4 …unpause

On Participant GDIS computer, select join server, select server, enter password "imroc", and select civilian (blue).

C2Node and SimOCU

1. (From the desktop) open a Linux Terminal window (right click on desktop).
2. (From the terminal prompt) type:

for SIMOCU: cd /irl/projects/imroc/exp4/oav/bin
simocu
for C2node: cd /irl/projects/imroc/exp4/c2node/bin
c2node
SIMOCU:
File—open—exp4_TRAINING_FINALhp.opf
Load mission—Perimeter.ovm

C2NODE
Select exp4.cnc

1. Experimenter should read purpose of study to participant:

"This is a joint project between IST/UCF and the Army Research Institute. The purpose is to test an integrated system for training operators of micro-unmanned aerial vehicle (MAV) operators and their commanders. The current effort will serve as a test phase for the technology and as a developmental effort for training. For the current study, you will be asked to operate two computer-based simulations: a command and control station called the C2Node {point to C2Node} and a first person shooter computer-based simulation called GDIS {point to GDIS}. First you will train and perform a series of tasks within the training environment. To ensure you can navigate within the simulation. If for any reason you do not perform the tasks in 3 attempts, you will be released from the study with credit for your time to that point. This is simply to ensure that you will be able to operate within a simulated environment and is no reflection on your ability in any other way. You will then be asked to perform a series of 4 'missions' where you must identify targets and positions of targets when asked. You will also be given a few surveys both before and after your simulation 'missions'. You should take part in this study only

because you want to and there is no penalty for not taking part. You have the right to stop at any time; just tell the researcher or a member of the research team that you want to stop and you will be compensated for the amount of time you actually participated. Any Questions? Would you like to participate?"

If participants agree ask them to sign:

Informed Consent

2. Next, participants will complete paper-based PowerPoint Based training for C2Node and GDIS. Experimenter should give them the paper based packet (Part 1). Tell the participant to read through the training and ask questions at any time:

Part 1: First 14 Slides. Let them read and then talk them show them the keyboard, mouse, and talk through the training map. IDENTIFY ALL ICONS ON MAP, INCLUDING WHERE THEY ARE STARTING. Show them how to rotate map, etc. GIVE THEM TRAINING FORM and show them where to write everything.

SHOW them the doctor and others on map.

- Periodically, you will also be asked to identify the position of the town Doctor that is assisting within the area
- When asked, you should pull up your map (O) and find the Doctor
- Then consult your paper map to determine what building the doctor is near.

Tell them they will report the position using the text feature in the C2Node, which will be covered in the 2nd part of the training session.

Give them the following instructions:

"Now you will practice and perform 3 tasks to ensure that you will be able to navigate through the game and perform. First spend a few minutes practice using the keys and mouse as outlined in your training to navigate."

When participant seems to be able to navigate, give them the following instructions (no more than 5 minutes):

"Now using this map, travel to the building labeled 11 on your map and practice opening the doors and exploring the building. Please try to go through every room. Make sure you find the stairs to the second floor, which are located on the outside of the building."

Let participants go to building. Help them get there if they are having trouble. Make sure they go in every room and find the stairs to the upstairs. Once they have explored the building, give them the following instructions:

“Now using the map, go to the building circled in blue on your map and see who (Soldier, medic, refugee) is in the building. Again, make sure you go through every room. Within this building is a tower, you can climb it if you would like, but it is not necessary to search there. Remember to write down the building number and how many Soldiers, refugees, and medics you find in the building on the form I gave you.”

Help the participants get to the building circled in blue (33). Give them hints along the way.

“Now using the map, go to the building circled in red on your map and see who (Soldier, medic, refugee) is in the building. Again, make sure you go through every room. Remember to write down the building number and how many Soldiers, refugees, and medics you find in the building on the form I gave you.”

Let participants go to building on their own. If they go to the wrong building, tell them they are in the wrong building and to try again. At this point, it is ok to give them a hint to as to where they went wrong.

“Now using the map, go to the building circled in green on your map and see who (Soldier, medic, refugee) is in the building. Again, make sure you go through every room. Remember to write down the building number and how many Soldiers, refugees, and medics you find in the building on the form I gave you.”

If they go to the wrong building again, tell them they are in the wrong building but do not give them a hint. If they go to the wrong building a third time, thank them for their participation and inform them they will get partial credit. If they go to the correct building, make sure they go in every room and find the stairs to the upstairs. Once they have explored the building, ask them who and how many people were in the building. If they answer wrong, explain to them what went wrong. Once this exercise is complete, give them the following instructions:

“Now you need to use both your paper map and the interactive game map to tell me what building Ted is near.”

“Which building is Phil near?”

“Which building is the doctor near?”

After they answer these questions, ASK THEM TO RETURN TO THE START POINT.

If participant gets all 3 correct, tell them to return to training to receive part 2. Experimenter should give them the next paper based packet (Part 2). Tell the participant to read through the training and ask questions at any time:

Part 2: rest of the slides. Let them read and remind them to ask questions along the way.
Part 2 consists of Slides 20 through 42.

Select take off for MAV and automation to follow path

Once the participants have been through training, give them the following instructions:

"Now you will take a few minutes to make sure you know how to use the C2Node or command and control unit. Please respond to the requests you receive in the text window."

Experimenter will show participant relevant cues in C2Node. MAKE SURE TO SHOW WHAT THEY ARE, THE MAV IS, AND THE VEHICLE IS. Also, how to use text and how to find grid numbers.

Experimenter should send picture of *** to participant using the SimOCU and text them the phrase: "Is there a hummer in picture 1?"

Participant should text back "***". If incorrect, tell participant what is in the picture.

Experimenter should send picture of *** to participant using the SimOCU and text them the phrase: "Is there a hummer in picture 2 ?"

Participant should text back "***". If incorrect, tell participant what is in the picture.

Experimenter should send picture of *** to participant using the SimOCU and text them the phrase: "Is there a hummer in picture 3 ?"

Participant should text back "***". If incorrect, tell participant what is in the picture.

Experimenter text participant the phrase: "Please identify the position of the MAV using the first 4 grid coordinates."

Experimenter text participant the phrase: "Please identify the position of the Doctor."

Participant should text back a 4 digit number for the MAV and the 2 digit number of the building for the Doctor. If incorrect, text and ask participant to report the position now of each up to 3 times.

***If participant cannot complete these requests, please thank them for coming and inform them they will receive credit for the time they have participated.

Inform participant that they have completed training and can now proceed to the performance missions. First they must complete the following surveys.

Following training, participants will complete while experimenter is loading mission maps:

1. Computer based NASA TLX
2. Demographics Questionnaire
3. Cube Comparison Test

Experimenter should continue to the appropriate protocol (Condition 1-4) and follow directions.